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NATIONAL RESEARCH COUNCIL

REPORT No. 23

The Storage of Apples in Air-Cooled Warehouses in Nova Scotia

Report of an Investigation Carried out under the Direction of the Associate Committee on Fruit Storage, by S. C. Lipsett, Ph.D.

CANADA

Published by the Authority of the Sub-Committee of the Privy Council for Scientific and Industrial Research

OTTAWA, 1928

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FOREWORD

In August, 1926, the Department of Natural Resources of the province of Nova Scotia requested the National Research Council to investigate the storage of apples in the warehouses of that province, with the object of determining conditions of storage which would reduce the considerable losses normally experienced and improve the quality of the apples being marketed. An Associate Committee on Fruit Storage was immediately appointed by the Council and a preliminary investigation was undertaken.

During the first season the work consisted chiefly of the observation of commercial storage of apples in air-cooled warehouses, under the supervision of Prof. W. S. Blair and Mr. J. F. Hockey of the Kentville Experimental Station of the Dominion Department of Agriculture. It was discovered that the methods in common use left much to be desired, and that in some cases the fruit might almost as well have been stored in the open.

The observations made during the preliminary investigation indicated that it might be possible, by the careful regulation of conditions, to improve greatly the usual storage practice. In order to determine the possibilities of scientific control the committee secured the services of Dr. S. G. Lipsett, to take temporary charge of one warehouse at the Kentville Experimental Station and to make further observations of the practice in other warehouses. Dr. Lipsett went thoroughly into the whole question of apple storage and has presented to the committee a detailed report, of which this publication is a brief summary.

In the preparation of this report an effort has been made to present Dr. Lipsett's findings and recommendations in such a way as to be of the greatest possible value to the important fruit-growing industry of Nova Scotia. It is submitted in the confident belief that, if the suggestions made are generally adopted, there will result a marked decrease in storage losses, a greater demand for Nova Scotia apples and a higher price, due to the improved quality of the product.

A. Stanley Mackenzie,
Chairman.
Associate Committee on Fruit Storage,
National Research Council.

August, 1928.

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THE STORAGE OF APPLES IN AIR-COOLED WAREHOUSES IN NOVA SCOTIA

INTRODUCTION

Nature of the Problem

In the province of Nova Scotia practically the whole apple crop is handled through the medium of the commercial warehouses. These warehouses, which are found in every fruit-growing centre, serve the double purpose of storing the fruit until required and of affording the means of packing for shipment. Those varieties of apples which mature early are graded and packed immediately on arrival, and are not usually kept in the warehouse for more than a few days. The later maturing varieties are stored from the time they are picked until required for the market, and as a consequence shipments of late apples may take place at any time during the winter or early spring.

No artificial means of refrigeration are used in the apple warehouses. In warm weather the temperature of the fruit is usually close to the average prevailing outside. During the months of October and November there are many periods when the temperature is high, and as a result heavy losses are frequently experienced through premature ripening and decay of the fruit, while excessive heat invariably impairs the quality of all the fruit in storage. From the early part of December until the end of the storage season weather conditions are usually such that the temperature of the fruit is nearly that found in cold-storage warehouses, but even the most favourable conditions during this period cannot compensate for the damage done by improper storage during the early part of the season.

The problem whose solution was sought in this investigation was therefore the determination of those conditions of storage which would result in the elimination of storage losses, and the placing of the crops upon the market in the best possible condition.

Ripening Processes

The storage of apples is complicated by the fact that a fruit, even after its removal from the tree, is a living thing, which continues certain life processes throughout its storage period. Complex

changes take place as the fruit ripens: starches are changed into sugars, sugars are oxidized to carbonic acid gas and moisture, which are given off, and considerable heat is evolved. As these processes go on the fruit becomes softer, and, if not otherwise disposed of, it eventually decays.

Importance of Keeping the Fruit Cool

These ripening processes take place much more slowly at low than at ordinary room temperatures. In fact, it is found in practice that the lower the temperature one can maintain, without permanently injuring the tissues, the longer the fruit can be stored in perfect condition. The ideal storage temperature varies slightly with the variety, but for all ordinary varieties of apples it is very close to the freezing point of water (32 degrees F.). At such a temperature apples will have many times the storage life possible at ordinary room temperatures. In an air-cooled warehouse it is unfortunately impossible to keep the temperature during warm weather anywhere near the freezing point. About the best that can be hoped for is to secure a temperature approximately equal to that prevailing during the night. Unfortunately, there are frequently nights with low winds or high temperature, when little if any cooling is possible.

Effect of Humidity

A second factor of some importance is humidity. If the humidity be very low, apples lose too much moisture by evaporation, and wilt. If, on the other hand, it be too high for any considerable period of time, the growth of moulds is likely to follow. Both of these troubles may be avoided by maintaining a relative humidity of approximately 85 per cent. When apples are stored in closed barrels or boxes the humidity of the warehouse air may fall somewhat below 85 per cent without causing wilt, since, due to evaporation from the apples themselves, the humidity of the air within the containers will normally be somewhat higher than outside. If the apples are stored in open containers the maintenance of 85 per cent humidity in the warehouse becomes important.

Removal of Foul Air

A third factor, which under certain conditions may be of some importance, is the removal of foul air containing the carbonic acid gas and other products of the ripening processes. In summer there is normally so much ventilation in warehouses that this factor may be entirely neglected, but in winter the lack of sufficient ventilation may at times lead to scald and other apple diseases.

Temperature Control

It follows from the above that in warm weather the first object in apple storage is to keep the temperature as low as possible. Since no artificial means of cooling the air are provided, temperature control is effected entirely by air circulation. Attention should therefore be directed towards securing the proper amount of air circulation and providing it at the right time.

In summer a person suffering from the heat frequently turns on an electric fan or otherwise provides air circulation, for one finds by experience that the body is ordinarily cooled thereby. In this case the cooling effect is due to two distinct causes. First, the air temperature indoors is almost invariably lower than that of the human body, so that one is cooled by the simple transfer of heat from the body to the circulating air. But there is a second cause —the evaporation of moisture from the surface of the body—which is frequently much more marked than the first. To such an extent is this true that when one is perspiring freely the body is cooled by a current of dry air, even though the temperature of the air be actually higher than that of the body.

With apples the situation is entirely different. The amount of moisture evaporated from their surface is very small; moreover, it is necessary to keep down this evaporation in order to prevent wilting. The result is that circulating air will cool apples only when its temperature is lower than that of the fruit itself; at any other time air circulation should be carefully avoided. To many, this fact will appear very obvious, but it is emphasized here because, as will be seen later, the circulation of air warmer than the fruit is the commonest and most serious mistake made in storing apples in warehouses.

OBSERVATIONS

Temperature

During the first storage season warehouses at Berwick and Port Williams were under observation, including altogether nine storage rooms. In all of these the control was entirely in the hands of the regular operators, and the results obtained may be taken as typical of present practice.

Temperature records were obtained by maximum and minimum thermometers, read at 8 a.m., 2 p.m. and 6 p.m., daily. These readings were supplemented by the use of ordinary thermometers and two recording instruments. Temperatures were taken both indoors and outdoors.

During the warm months of October and November, when it was particularly important that the warehouses should be kept as

cool as possible, the average temperature inside the various storage rooms was about 2·5 degrees F. *higher* than outside. In other words, not only were the warehouses ineffective in keeping the apples cool, but they were so regulated as to be worse than useless for this purpose. The fruit would actually have been cooler if simply kept outdoors in the shade during this period.

One very common fault in warehouse regulation is the admission of fruit during the hot part of the day. Not only does this involve the admission of a great volume of warm air but the incoming fruit is usually at a high temperature and warms considerably the fruit already in the warehouse.

Humidity

Humidity determinations were usually made with sling psychrometers. One recording instrument was used. In general, humidities were fairly satisfactory, averaging slightly over 80 per cent. Had the temperature been kept lower the humidity would probably have been higher, due to the lower capacity of cool air for moisture.

Air Circulation

Air velocity through ventilators was determined occasionally by means of a anemometer. The openings provided for ventilation were too small, since a high wind velocity was found necessary to give sufficiently rapid air changes.

Wind

Wind velocity is a very important factor in air regulation. Unfortunately, as the observations showed, the velocity of the cool westerly winds averages lower during the cooler parts of the night, when ventilation is particularly effective, than during the daytime when the outside temperature is high. When, therefore, ventilators are left open all the time the result is bound to be that observed—a higher average temperature inside than outside the warehouse—since more warm air is admitted during the day than the lower wind velocity will blow in at night. Moreover, at night it is common practice to place slats over the openings, and thereby further decrease the already small volume of cool air entering.

Ripening

Ripening tests were carried out with a Magness and Taylor pressure tester. A barrel of each of eight varieties of apples was

divided into three boxes, and these were then stored in separate rooms. Pressure tests were carried out at intervals to determine the progress of maturity, but temperatures and humidities were too nearly alike in all the experiments to show appreciable differences in the rate of ripening.

Later Observations

During the second season observations were continued of the ordinary practice in apple storage, and particularly of the effect of methods of construction and operation of warehouses upon temperature control. The necessity of carrying out numerous experiments and of exercising control over a number of storage rooms did not permit of continuous records of conditions in the commercial warehouses, but the observations made very generally confirmed those of the first season on the ineffectiveness of ordinary storage methods in keeping the fruit cool.

Bad Management of Warehouses

The outstanding mistake made in warehouse control is in continuing air circulation when the temperature of the air is higher than that of the fruit which it is desired to cool. For example, in one warehouse, on November 16, 1927, at 10 a.m., after some days of cool weather, the temperature of the fruit was 45 degrees F. and that of the outside air 60·6 degrees. All the warehouse doors were open and a strong wind was forcing warm air in with a velocity of 660 feet per minute. The air was found to leave the warehouse at 53·6 degrees, showing that it had been cooled seven degrees in the process of heating up the fruit. By 3 p.m. of the next day the temperature of the fruit averaged 55 degrees, a rise of 10 degrees in 29 hours. Those barrels of apples nearest the air inlets were at a temperature of 69·5 degrees. Obviously, the doors should have been kept tightly closed during this warm period.

Sweating

Moreover, in this case trouble was caused by so-called "sweating" of the apples. The warm humid air entering the warehouse was cooled so rapidly that moisture quickly condensed on the apples, which were as wet as if they had been sprayed. This is the same phenomenon so frequently observed in the case of the sweating of a jug filled with cold water, where the drops are the result of condensation, and do not come from the interior. Sweating is very harmful to apples, since it greatly promotes the growth of moulds and hastens decay.

Variations in Temperature of the Fruit

It has been found that the temperature of the fruit in different parts of warehouses often varies considerably. This is particularly true when there is considerable circulation of air, the fruit next the air inlets being closest to the temperature of the outside air. When air circulates freely through a warehouse there is not usually much difference between the temperatures at the floor and ceiling, but in warehouses which have been closed for some time this difference may be considerable, since the air heated by contact with the walls or by other means rises to the highest part of the storage room.

There may at times be a considerable temperature difference in the various parts of a closed barrel. When apples are being rapidly cooled by circulating air the convection currents set up within the barrels usually result in the fruit being coolest on the bottom and near the outside of each barrel, while if the circulating air be warmer than the fruit the apples on top and near the outside are the warmest.

Boring holes in barrels was found to make no appreciable difference in the rate of cooling.

EXPERIMENTS

Volume of Air Required

For the correct design of air-cooled warehouses it is essential to know how much air will be required to keep the temperature within reasonable limits. It is not sufficient to plan for average conditions; the cooling facilities must be such as to take care of even the unusual conditions which may be encountered from time to time.

Many calculations of the efficiency of ventilation have been based on an incorrect statement made in the literature that to cool a bushel of apples one degree there are required 50 cubic feet of air at a temperature five degrees below that of the apples. Warehouses designed on this basis will be greatly underventilated, for a simple calculation shows that almost ten times that volume is necessary, or about 1,400 cubic feet per barrel. If the circulated air be not cooled as much as five degrees by the fruit it is obvious that a correspondingly larger volume of air is required.

An attempt was made to confirm experimentally the correctness of this figure. A warehouse containing a known number of barrels of apples was ventilated with a definite volume of air, the

temperature of which was measured on entering and leaving the building. The cooling of the fruit was determined by taking temperature readings in a number of barrels situated in different parts of the warehouse. The result obtained checked the calculated value.

Heat Generated by the Fruit

To determine the area of openings required to properly ventilate a warehouse allowance must also be made for the heat generated by the fruit. It is not feasible to determine this when ventilation is being carried on, but an approximate value was obtained by closing up a warehouse tightly for some days and making allowance for the heat entering through the walls and roof. In this way it was found that at a temperature of about 50 degrees C. the fruit would heat from one to one and a half degrees in 24 hours, the amount varying with the variety.

This figure was checked by calculation, as follows:—Bulletin No. 1406, of the United States Department of Agriculture, gives the results of determinations of the rate of liberation of carbonic acid gas from Baldwin apples at different temperatures. Assuming that the gas was formed by the oxidation of sucrose the heat evolved was calculated to be sufficient to warm the apples 0·2 degrees in 24 hours at 32 degrees F., 0·6 degrees at 40, 1·2 degrees at 50, 2·0 degrees at 60, and 4·0 degrees at 85. These figures also show the relative rates of ripening at the different temperatures.

From the above it will be seen that if the fruit is to be gradually cooled over a considerable period the facilities provided for this purpose will have to be more than sufficient to take care of this heat generated by the ripening of the fruit, as well as any heat entering through the warehouse walls and roof. If we take two degrees of cooling per 24 hours as the minimum to be provided for and assume that this cooling has to be done between 6 p.m. and 7 a.m., we find that for a warehouse containing 4,000 barrels of apples the volume of air circulated and cooled five degrees will have to be about 860,000 cubic feet per hour, involving the circulation every $2\frac{1}{2}$ minutes of as much air as would fill the warehouse when empty. Even with this enormous volume of air being circulated the temperature of the fruit will normally not be lowered more than one degree in 24 hours.

Flues and Doors

It is well known that warm air rises. It is obvious, therefore, that the best place for removing air from a warehouse room is near the ceiling. In cellars this is usually possible, since the air passes out of windows placed high up or through hatches in the

ceiling. On the main floors, however, the air goes out mainly through the doors, which ordinarily extend only about half way to the ceiling. If portholes are provided near the ceiling or there are flues in the ceiling these will remove the warmest air. When very little wind is blowing this is of some importance, in high winds it is not.

As an illustration of this point, in one warehouse the air entered at 36 degrees F. at the rate of one cubic foot per barrel per minute. That issuing from the door was at an average temperature of 44·3 degrees, while that going up a flue in the ceiling was 46·7 degrees.

Some investigators have recommended that flues from the ceiling through the roof be the chief means of removing air. A number of experiments were therefore carried out to determine the relative value of flues and doors.

One experiment was performed when the wind was blowing and the temperatures inside and outside the warehouse were the same. Under these conditions there was no warmer air to rise through the flue, and any movement there was due to the wind pressure alone. The free area of the slatted doors on the windward and leeward sides was the same, 18·5 square feet, while the area of a cross-section of the flue was 15 square feet.

First, only the two doors were opened. Air then entered at a velocity of 1,010 feet per minute. When the flue also was opened the velocity rose to 1,040 feet per minute, the smallness of the increase being due to the fact that there was already sufficient room for the air to escape. With the exit door closed the velocity was only 540 feet per minute, the reduction no doubt being due to friction in passing up the long flue.

Flues are of most value when the temperature outside is lower than inside a warehouse and no wind is blowing to cause air circulation. A considerable number of experiments were performed under such conditions, and it was found that on an average, when there was a difference of 5 degrees between the inside and outside temperatures, and no wind was blowing, a velocity of 150 to 200 feet per minute would be secured in a flue 18 feet long and extending from the main floor through the roof. Through a 30-foot flue from the cellar the velocity under the same conditions was 200 to 250 feet per minute. If the flues are large, considerable ventilation may be provided in this way.

The value of flues depends largely upon the facility with which air can escape at the top. The top itself is usually covered to keep out rain and snow, and provision is made for the passage of air through louvers. It has long been recognized that very frequently such louvers materially reduce air circulation. In one

flue tested, the velocity of air immediately before and after removing the louvers was found to be 150 and 400 feet per minute, respectively. At that time a wind of 13 miles per hour was blowing. It should be remembered, however, that such large differences in air velocity are to be found only in fairly high winds, when ventilation is likely to be ample even without the flues. The same applies to the use of revolving ventilators on top of flues. In one flue thus equipped the air circulation with a wind velocity of 10 miles per hour was more than twice that of a flue not so equipped, while with no wind the circulation was the same in each case. The Dominion Department of Agriculture recommends that barn flues be equipped with cupolas of the open type.

Hatchways

A study was made of the flow of air through slatted hatchways provided in the ceilings of cellar storerooms. There can be no doubt that some air does flow through them, even when there is no wind blowing, but the velocity is usually too low to be measured with an anemometer. They provide additional space for the escape of air when insufficient openings have been left on the leeward side of a building, but cannot be considered as of much importance in warehouse ventilation.

Aisles

Considerable difference of opinion has existed as to the necessity for leaving unobstructed aisles in warehouses for the free passage of air. It seems probable that when apples are packed in rectangular boxes some such provision should be made. With barrels, however, there is so much space between them, even when packed as closely together as possible, that this is not necessary. In one case a solid block of barrels was built up from the floor to the ceiling across a warehouse. The volume of air circulating was the same as with the top tier of barrels entirely removed. The air would be better distributed with all the barrels in place, so that cooling might be slightly more effective without aisles or other large air passages. It is nevertheless important that openings for the entrance and escape of air should not be blocked with barrels or otherwise, since the air velocity is high at these points and any interfering objects would reduce the volume passing.

Good and Bad Management

While it is essential to provide for sufficient air circulation when the outside temperature is lower than that of the fruit it is

equally important to stop all circulation when the outside air is the warmer. The following example of the difference between good and bad management will illustrate the latter case:

About the middle of November, 1927, the apples in one warehouse, both main floor and cellar, had been cooled to 39 degrees F. Then the weather suddenly turned warm for some days, during which period the warm winds blew freely through the main floor of the warehouse, both night and day. At the end of five days the temperature of the fruit varied from 61 to 70 degrees.

During the whole of this period the cellar of the same warehouse was kept tightly closed, and in five days the temperature of the apples was only 46 degrees. The rise of seven degrees noted was due in the main to the heat generated by the apples themselves, and could not have been avoided without artificial refrigeration. It is worthy of note that at 46 degrees the fruit could be kept in good condition about three times as long as at 70 degrees.

Air Circulation in Winter

As regulated air circulation in warm weather can be used to keep fruit cool so in cold weather it can be taken advantage of to keep it from freezing. In general, apples will not be damaged even if kept for long periods at 30 degrees F., but in practice it is advisable not to carry the temperature regularly below 34 degrees, in order to allow a fair margin of safety in case of protracted cold weather. If the temperature of the fruit falls below this point, advantage should be taken of the first warm day to circulate sufficient air to restore the necessary margin of safety. As a rule, however, even in winter, some cooling is required.

RECOMMENDATIONS

Having given a summary of the observations recorded and the more important experiments carried out in this investigation an attempt will now be made to outline practical methods of warehouse construction and control.

Warehouse Sites

Since wind is the most important factor in regulating the temperature of warehouses in warm weather it is essential to choose a site where full advantage can be taken of any wind that blows.

This means that the building should be erected in an exposed position, and particularly where the force of the cool north and west winds is not broken by trees. If this precaution is neglected the volume of air entering a warehouse may be reduced to a quarter of what it would be in an exposed position.

Warehouse Construction

In general it may be said that warehouses of moderate size are to be preferred to very large warehouses, since the difficulties of cooling increase considerably with the size. The usual size of about 40 by 100 feet is quite satisfactory.

It pays well to put a moderate amount of insulating material on the roofs as well as the sides of warehouses. In summer this will prevent the heat of the sun from striking through. Ample insulation is essential in winter to keep the fruit from freezing in protracted cold weather.

For similar reasons warehouses should be so built that there will be but little air infiltration through the walls and around the windows, doors and other openings. A tight warehouse can be comparatively free from undesirable air circulation, both summer and winter.

Openings for air circulation are usually provided only on the sides of a warehouse, with none on the ends. This is a serious mistake, since with winds blowing directly on either end very little ventilation can be secured by opening the side doors and windows. Side openings should be provided sufficient to give 4 cubic feet of air per minute for each barrel of apples in a warehouse with an air velocity of 200 feet per minute (equal to about $2\frac{1}{4}$ miles per hour). With 3,000 barrels of apples this will require 60 square feet of clear openings on each side. If slatted doors are used at night, and the effective opening is thereby reduced by half, twice as much total area should be provided. If the openings must be protected to keep out intruders it should preferably be done by heavy wire netting, which will not appreciably reduce the air circulation. As a rule the working doors on the sides are sufficiently large to provide the necessary air circulation, if properly spaced. The end openings, also properly spaced, should have at least half the total area of those on the sides.

In those districts where electric light is available it is well to dispense with windows entirely. Windows admit much heat in warm weather, particularly when they are on the south side, and considerable cold in winter. Moreover, they are of little value for lighting, since barrels are frequently piled in front of them.

When openings other than working doors are provided for air circulation it is desirable to have them open outwards, since when

a warehouse is full there is seldom ready access to such openings from the inside. Permanent wire netting may be provided on the inside, and insulated doors on the outside.

The estimates just given apply to the main floor of a warehouse of the capacity given. Where a cellar provides a like capacity under the main floor it requires openings of similar area. These should be well distributed along the sides and ends, and should preferably be placed at or near the cellar ceiling. They should be closed with insulated doors swinging outwards instead of with windows.

In all of the above it is assumed that no vertical ventilating flues are provided. Where these exist or are planned for in a new building deductions may be allowed in the areas of openings on each side of half the cross-sectional area of the flues, since the latter are, except when the wind is very low, only about half as effective as doors and windows. This applies alike to the main floor and the cellar.

If flues are provided they should be so constructed as to allow the free escape of air at the top. An open top capped by a cupola is better than louvers. Revolving ventilators are of some advantage, but this is about balanced by the extra cost.

Many Nova Scotian warehouses are constructed with a number of small holes about 6 by 12 inches distributed just beneath the ceilings of main floors and cellars, and connected inside with flues. This practice is to be commended, for, although they are too small to have much cooling effect in the fall, they are of value in admitting a small quantity of air in winter. Their small size is an advantage in that it avoids the danger of freezing the fruit, particularly since they admit cold air at the ceiling where it has an opportunity of being warmed before it comes in contact with the fruit. It is good practice to provide slats in the bottom of the flues leading from these small openings in order to better distribute the cold air in very severe weather.

Motor-driven fans have been recommended by some for use in the warmer weather prevailing in the early fall. Their cost is considerable, however, and it is much cheaper to provide the same cooling capacity by means of openings on the sides and ends.

Warehouse Control

Given a properly constructed warehouse it should be the object of the warehouseman to so control its operation as to keep the fruit in the best possible condition until shipped to market.

First of all, apples should be reasonably cool when put into storage. This will usually be insured if the growers will bring their fruit to the warehouse in the early morning, when it has been well cooled by standing all night in the open. When this cannot be arranged the barrels may be stored in the open at the warehouse until the temperature is favourable, that is, until the outside air is at least as cool as the fruit in the warehouse.

To be sure, it is sometimes necessary to open doors even in warm weather for the receipt or shipment of fruit, or for other reasons. In such a case care should be taken to see that only one door is open at a time. This will keep air circulation down to a low point, since if there be no free exit for air it will not enter in large quantity.

During warm weather, or in the fall when the temperature of the fruit is above 34 degrees F., doors and windows in the warehouses should be kept open whenever the temperature outside is lower than that of the fruit. When the outside temperature is above that of the fruit every opening should be closed—the failure to do this is the most serious fault in present storage methods.

Ordinarily this means that the openings will be tightly closed during the day and wide open at night. One not uncommonly finds, however, that the air temperature even in the daytime is lower than that of the fruit, when air circulation may to advantage be continued. So also there are many nights when, due to the high temperature prevailing, the doors and windows should be kept tightly closed. And it can scarcely be too strongly emphasized that one should not rely on his own judgment, but on accurate thermometers, to inform him of both outside and inside temperatures.

During the winter considerable care is required to maintain the best possible temperature in warehouses. Some think that careful control does not pay, since the temperature is always reasonably low, but this is a serious mistake. At 34 degrees F. apples will keep six months as readily as threee months at 40 degrees, and if the longer storage period is not required they will keep for the shorter time in much better condition.

Cooling of the fruit is frequently required, even in winter, due to the generation of heat in the ripening process. It should not be allowed to go much above 34 degrees F., nor is it safe to cool it much below this, since it will be damaged below 27 or 28 degrees, and some of the fruit may be colder than supposed, due to variations in different parts of a warehouse.

Not much trouble is likely to be experienced from low or high humidity. The warehouseman should nevertheless keep a close

check on the condition of the fruit, and at the first sign of wilting the warehouse floor should be kept continuously wet. Headed barrels of apples are less likely to wilt than those left unheaded. Too high humidity is indicated by the presence of moulds on the apples. If this condition occurs in cold weather it can usually be corrected by increased circulation, since at such times the outside air contains very little moisture.

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